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सौर तापीय ऊर्जा – पारिभाषिक शब्दावली

Indian Standard

SOLAR ENERGY — THERMAL APPLICATIONS — VOCABULARY

UDC 697·7·620·91 : 001·4

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 22 March 1990, after the draft finalized by the Solar Energy Sectional Committee had been approved by the Heavy Mechanical Engineering Division Council.

The terminology of the terms used in any field are always useful for better commercial understanding. This standard gives a classified list of terms and letter symbols used in the field of solar thermal energy and their definitions.

This standard is based on ISO/DP 9488 'Solar energy — thermal application — vocabulary' issued by the International Organization for Standardization (ISO).

Indian Standard

SOLAR ENERGY — THERMAL APPLICATIONS — VOCABULARY

1 SCOPE

1.1 This standard defines terms relating to thermal applications of solar energy.

2 TERMS AND DEFINITIONS

For easy reference and use, the term and definitions have been classified as given below.

2.1 Solar Geometry

2.1.1 *Aphelion*

The point in the earth's orbit, when it is farthest from the sun, approximately 152×10^6 km.

2.1.2 *Perihelion*

The point in the earth's orbit when it is closest to the sun, approximately 147×16^6 km.

2.1.3 *Solar Declination*

The angle subtended between the earth-sun line and the plane of the equator (north positive), zero on equinox dates, varying between $+ 23{\cdot}45^\circ$ (June 22) and $- 23{\cdot}45^\circ$ (Dec 22).

2.1.4 *Azimuth* (*Angle*)

The arc of the horizon (in degrees) intercepted between a given point and an adopted reference direction : usually the true north, and measured in a clockwise direction, 0 to 360°.

2.1.5 *Solar Aximuth* (*Angle*)

The projected angle between a straight line from the apparent position of the sun to the point of observation and due north. The angle is measured clockwise using the projections on the local horizontal plane, 0 to 360°.

2.1.6 *Solar Altitude* (*Angle*)

The angle between a straight line from the apparent position of sun to the point of observation and the horizontal plane through that point of observation.

2.1.7 *Zenith*

The highest point of the sky hemisphere, the point vertically above the observer.

2.1.8 *Zenith Angle*

The angular distance of the sun from the vertical, that is the angle subtended by a vertical line to the zenith and the line of sight to the sun, that is 90° minus the solar altitude angle.

2.1.9 *Solar Hour Angle*

An angle of 15° for each hour measured from solar noon, negative for morning hours and positive for afternoon hours, that is $\text{SHA} = 15^\circ$ at ($\text{Hr} = 13$).

2.1.10 *Solar Noon*

For any given location solar noon is the local time of day when the sun is at its highest altitude for that day, that is the time when the sun crosses the observer's meridian.

2.1.11 *Solar Time*

The hour of the day as determined by the apparent angular motion of the sun across the sky with solar noon as the reference point for 12 o'clock.

2.1.12 *Sunset Hour Angle*

The hour angle occurring at sunset.

NOTE — Many different definitions exist for 'sunset'; the most generally used is the geometric definition : the time when the centre of the sun's disk coincides with the extension of the observer's horizontal plane.

2.1.13 *Orientation* (*Angle*)

The direction, a collector (or a building) faces, expressed as the azimuth angle of the horizontal projection of the surface normal.

2.1.14 *Angle of Incidence*

The angle between the direct radiation and the plane of the absorber.

2.1.15 *Sun-Path Diagram*

A graphic representation of solar altitude versus solar azimuth, showing the position of the sun from sunrise to sunset for various dates of the year.

NOTE — Many different projection methods are in use.

2.1.16 *Heliodon*

A solar angle simulator, useful in conducting shading assessments on buildings or collector arrays, usually having a model table, tilting for the latitude, rotating for the hour of day, using a lamp to represent the sun, at some distance away, mounted on a vertical rail, allowing adjustment for the date (for declination).

2.1.17 *Solarscope*

A device similar to the heliodon, but having a fixed horizontal model table and a light source movable to any solar altitude and azimuth.

2.1.18 *Meteorological Range*

The distance V at which the threshold contract, between a black and white target is 0·02.

$$V = \frac{1}{\sigma} \ln \frac{1}{\epsilon}$$

Thus V is a function only of the atmospheric extinction coefficient σ.

2.1.19 *Angle of Inclination*

Angle between the absorbing surface of the collector and the horizontal.

2.2 Radiation Terms

2.2.1 *Radiation*

The phenomenon of energy transfer in the form of electromagnetic waves.

2.2.2 *Radiant Energy*

The energy of electromagnetic waves.

2.2.3 *Radiant Flux*

Power emitted, transferred or received in the form of radiation.

2.2.4 *Ultraviolet Radiation*

Electromagnetic radiation with wavelengths shorter than visible light (shorter than approximately 380 nm) and longer than X-rays.

2.2.5 *Visible Radiation*

Radiation with wavelengths that stimulate the human optic nerves. Visible radiation lies approximately within a wavelength band of 380 nm and 780 nm.

2.2.6 *Infrared Radiation*

Electromagnetic radiation of wavelengths between 780 nm and approximately 1 nm.

2.2.7 *Shortwave Radiation*

Radiation with wavelengths less than 3 m.

2.2.8 *Longwave Radiation*

Radiation originating from sources at terrestrial temperatures, (for example ground and other terrestrial objects), thus substantially all at wavelengths greater than 3 μm. (Sometimes called 'thermal radiation').

2.2.9 *Total (Incident) Radiation*

The integrated value of radiation of all wavelengths.

2.2.10 *Solar Radiation*

The radiation emitted by the sun. (Practically all the solar radiation incident at the earth's surface is at wavelengths less than 3 m and is often termed 'shortwave radiation'. Use of the latter term in this sense is discouraged).

2.2.11 *Solar Energy*

The energy emitted by the sun in the form of electromagnetic energy (Primarily in the wavelength region from 0·3 to 3·0 μm) or any energy made available by the reception and conversion of solar radiation.

2.2.12 *Solar Flux*

The radiant flux originating from the sun.

2.2.13 *Solar Spectrum*

Wavelength distribution (or frequency) of electromagnetic radiation emitted from the sun.

2.3 Radiation Quantities

2.3.1 *Irradiance*

Flux of radiation per unit area (at a point on a surface); quotient of the flux of radiation incident on an infinitesimal element of the surface containing the point under consideration, by the area of the element. Irradiance is normally expressed in watts per square metre (W/m^2).

NOTE — Solar irradiance is often termed 'incident solar radiation intensity', instantaneous insolation' or 'incident radiant flux density'.

2.3.2 *Irradiation*

Integrated total irradiance normal to the plane of the collector aperture whose effect on the thermal output of the collector would be the same as that of the integrated total solar radiation. Irradiation is normally expressed in megajoules per square metre (MJm^{-2}).

2.3.3 *Insolation*

An imprecise term, may mean the radiation received from the sun, solar irradiation or irradiance, or in a general sense : sunlight penetration. Its use is deprecated.

2.3.4 *Direct Solar Radiation*

Solar flux coming from the solid angle of the sun's disk on a surface perpendicular to the axis of that solid angle. In conventional instruments the acceptance cone includes a plane angle of about 6 degrees. (It is measured in watts per square metre).

2.3.5 *Diffuse (Solar) Radiation*

Diffuse solar radiation is the hemispherical solar radiation minus the radiation received from a small solid angle centered on the sun's disk.

NOTE — This solid angle should be equal to that of the field-of-view angle mentioned in 3.4 and then the sum of the direct solar radiation component normal to the receiver plane and the diffuse solar radiation is equal to the hemispherical solar radiation.

2.3.6 *Global (Solar) Radiation*

The hemispherical solar radiation received by a horizontal plane surface.

2.3.7 *Circumsolar Radiation*

Radiation scattered by the atmosphere so that it appears to originate from an area of the sky immediately adjacent to the sun. It causes the solar aureole.

2.3.8 *Hemispherical (Solar) Radiation*

The solar radiation received by a plane surface from a solid angle of 2π steradians.

NOTE — More than 99% of the hemispherial solar radiation at the earth's surface is contained within the wavelength range from 0 3 μm to 3·0 m. Generally the hemispherical solar radiation is composed of the direct solar radiation and diffuse solar radiation (solar radiation scattered in the atmosphere) as well as of solar radiation reflected by the ground.

2.3.9 *Atmospheric Longwave Radiation*

(Syn. with the deprecated term 'sky radiation') The thermal radiation emitted by gases and particles in the atmosphere.

2.3.10 *Sky Radiation*

A deprecated term, as it can mean either 'atmospheric radiation', or 'diffuse (solar) radiation'.

2.3.11 *Extra-Terrestrial Solar Radiation*

Solar radiation received at the outer limit of the earth's atmosphere.

2.3.12 *Solar Constant*

The solar irradiance outside the earth's atmosphere on a plane normal to the direction of this radiation, when the earth is at its mean distance from the sun (149·5 × 10^6 km). The solar constant value so defined is 1 367 W/m^2, but may be revised within ± 7.

2.3.13 *Direct (Solar) Irradiance (Beam Irradiance)*

Irradiance produced by direct radiation on a given plane.

2.3.14 *Irradiance, Average*

Integration of irradiance over a specified time interval, divided by that time interval.

2.3.15 *World Radiometric Reference (WRR)*

The WRR is a scale (reference) representing the SI units of irradiance with an uncertainty of less than ± 0·3 percent.

2.3.16 *Altazimuth Mount*

A tracking mount capable of rotation about orthogonal altitude and azimuth axes; tracking may be manual or by a follow-the-sun servomechanism.

2.3.17 *Solar Irradiance, Spectral ($E\lambda$)*

The solar irradiance per unit wavelength interval at a given wavelength. Units W.m^{-2}, m^{-1}.

2.3.18 *Transmittance, τ*

The ratio of the transmitted radiant flux to the incident flux.

2.3.19 *Radiant Exposure H*

Time integral of irradiance.

2.4 Radiation Measurement

2.4.1 *Radiometer*

Instrument used for measuring radiation (the output of the instrument can be either irradiance or irradiation).

2.4.2 *Pyrradiometer*

An instrument for measuring the total radiation on a plane surface from a solid angle of 2π steradians.

2.4.3 *Pyranometer*

Instrument for measuring the radiation on a plane receiver surface which results from the radiant fluxes incident from the hemisphere above within the wavelength range of 0·3 to 3 m.

NOTE — The given spectral range represents roughly the spectral range of solar radiation (also called solar or short wave range) at the ground and is only nominal. Depending on the material used for the domes which protect the receiver surface of a pyranometer the spectral limits of its responsitivity meet more or less accurately the above-mentioned limits.

2.4.4 *Solarimeter*

A specific type of pyranometer. Its use as a synonym for pyranometer is deprecated.

2.4.5 *Spectral Pyranometer*

An instrument for measuring solar radiation over restricted wavelength ranges.

2.4.6 *Pyrheliometer*

Are radiometers designed for measuring the irradiance which results from the solar radiant flux from a well defined solid angle whose axis is perpendicular to the plane receiver surface.

NOTE — According to this definition pyrheliometers are applied to measure direct solar radiation at normal incidence. Typical field-of-view angles of pyrheliometers range from 5° to 10°.

2.4.7 *Sunshine Recorder*

An instrument which records the time interval during which solar radiation reaches sufficient intensity to cast distinct shadows.

NOTE — The threshold value of direct irradiance of 120 ± 24 W/m^2 has been suggested.

2.4.8 *Isohel*

Curve (drawn on a map) of equal sunshine duration during a given interval of time.

2.4.9 *Isorad*

Curve (drawn on a map) of equal solar irradiation during a given interval of time.

2.4.10 *Field Pyrheliometers*

Pyrheliometers which are designed and used for long term field measurements of direct solar radiation. Generally these pyrheliometers are weather-proof encased. The receiver is protected from wind, dirt, rain, snow and insects by a window (of quartz) or alternatively by strong ventilation.

2.4.11 *Solar Irradiance Simulator*

A source of radiative energy simulating the solar radiation. Enables a solar domestic water heater to be tested under standard conditions of ambient temperatures, wind and radiation intensity.

2.4.12 *Standard Pyrheliometers*

Standard pyrheliometers are pyrheliometers of any class serving as reference in calibration procedures. They are selected and well tested instruments, the long time drifts of sensitivity of which are relatively low, controlled on a routine basis by comparisons with other standard pyrheliometers.

NOTE — Generally standard pyrheliometers are operated without protecting windows. To achieve the above-mentioned stability of the sensitivity, the use of a standard pyrheliometer should be restricted to comparisons and calibration activities. The instrument should be stored carefully in a laboratory of moderate climate.

2.4.13 *Primary Standard Pyrheliometers*

Primary standard pyrheliometers are recruited from the group of absolute pyrheliometers (also called absolute radiometers).

2.4.14 *Secondary Standard Pyrheliometers*

Secondary standard pyrheliometers, are pyrheliometers of high precision and stability whose calibration factors have been derived from primary standard pyrheliometers. The group comprises absolute pyrheliometers which do not fulfil the requirements of primary standard pyrheliometers, as well as compensation pyrheliometers and some other precise but historical instruments like the silver disk pyrheliometer.

2.4.15 *Pyrgeometer*

An instrument for determining the irradiance on a plane receiving surface which results from the radiant fluxes incident from the hemisphere above within about the wavelength range 4 μm to 50 μm.

NOTE — The given spectral range is nearly identical with those of the so-called terrestrial radiation or longwave radiation and is only nominal. Depending on the material used for the domes which protect the receiving surface of a pyranometer the spectral limits of its responsivity meet more or less accurately the above-mentioned limits.

2.4.16 *Pyrheliometer, Absolute (Self-Calibrating)*

A radiation sensor for determining the direct solar irradiance having a field of view of 5 degrees and a slope angle of 0·75 to 0·8 degrees and having a blackened cavity receiver for absorption of the incident radiation; the measured electrical power in a heater affixed to the cavity receiver constitutes the method of self-calibration and traceability to absolute SI units; the sensing of the temperature rise of the receiving cavity is employed to either relate the radiation quantity to the SI electrical quantity (passive) or to control the heater to stabilize cavity temperature at a desired set-point (active).

2.4.17 *Pyranometer, Reference*

A well maintained pyranometer selected according to its stability and quality and used principally to calibrate other instruments.

2.4.18 *Integrating Sphere*

A sphere of from 1 to 4 m in diameter with a planar segment (usually a horizontal bottom segment) provided on which to mount pyranometers to be compared with an artificial light source, the sphere wall being coated with a flat white paint (as lambertian as possible to provide a nearly uniform irradiance).

2.4.19 *Pyrheliometer, Secondary Reference*

A pyrheliometer essentially meeting WMO first class specifications but not having self-calibrating capability.

2.4.20 *Tilt Angle*

The angle between the vertical and the pyranometer axis which is identical to the angle between the horizontal plane and the plane of the detector surface

2.4.21 *Field-of-View Angle of a Pyrheliometer*

The field-of-view angle of a pyrheliometer is the full angle of the cone which is defined by the center of the receiver surface and the border of the aperture, if the latter is circular and concentrical to the receiver surface; if not, effective angle may be calculated.

2.4.22 *Solar Tracker (or Sun Tracker)*

Solar trackers are power driven or manually operated with movable supports which must be employed to align a pyrheliometer to the sun. "Equatorial trackers" are sun-following devices which have an axis of rotation pointing towards the elevated pole; the axes of motion are the hour angle and the declination of the sun. "Altazimuth trackers" are sun-following devices with the solar elevation angle and the azimuth angle of the sun as coordinates of movement.

2.4.23 *Sun Shading Disk Device (Short : Shade Disk Device)*

A device which allows to move a disk in such a way that the sun is always screened from the receiver of a radiometer (for example a pyranometer). For calibration purposes quick removal of the disk is mandatory.

2.4.24 *Calibration of a Radiometer*

Calibration of a radiometer means the determination of the absolute responsivity or the calibration factor as its reciprocal of a radiometer under well defined measurement conditions.

2.5 Radiation Properties and Processes

2.5.1 *Asorptance (Solar)*

The ratio of the amount of solar radiation absorbed by an element of a surface to the amount of such radiation incident on it.

2.5.2 *Emittance*

The ratio of the radiant energy emitted by a body to the energy emitted by a blackbody at the same temperature.

2.5.3 *Reflectance*

The ratio of radiation reflected from a surface to the radiation incident on that surface which is dependent on wavelength of radiation and angle of incidence.

2.5.4 *Reflectance, Hemispherical*

The ratio of all of the flux leaving a surface or a medium by reflection, within a solid angle of 2 steradians, to the incident flux.

2.5.5 *Albedo*

Ratio of the solar radiation reflected by a surface, to that incident on it. A generalised term for the average reflectance of a defined surface area (usually of the earth or clouds) in technical applications its use is discouraged, the preferred term is 'reflectance'.

2.5.6 *Air Mass*

The ratio of the mass of atmosphere in the actual observer-sun path to the mass that would exist if the observer was at sea level, at standard barometric pressure, and the sun was directly overhead.

NOTE — Air mass varies with the declination of the sun and the local barometric pressure which changes with altitude.

2.5.7 *Attenuation*

The reduction of radiation flux over a given path length, due to absorption and scattering.

2.5.8 *Scattering*

Interaction of radiation with matter, where its direction is changed but the total energy and wavelength remain unaltered.

2.5.9 *Sky Temperature*

The atmospheric radiation received at a surface may be expressed in terms of an equivalent blackbody radiation temperature, which is the sky temperature.

2.5.10 *Angstrom*

Unit of length : 10^{-10} m or 0·1 nm. (Its use is discouraged, the preferred unit is the nano-metre: 1 nm = 10 Å.)

2.5.11 *Air Mass Zero (AMO)*

Describing solar radiation quantities outside the earth's atmosphere at the mean earth-sun distance.

2.6 Collector Types

2.6.1 *Collector, Solar Thermal*

Device containing an absorber.

2.6.2 *Liquid Type Collector*

A solar collector that uses a liquid as the heat transfer fluid.

2.6.3 *Air Type Collector*

A solar collector that uses air as the heat transfer fluid.

2.6 4 *Collector, Flat Plate*

A non-concentrating solar collector in which the absorbing surface is essentially planar.

2.6.5 *Collector, Concentrating*

A solar collector that uses reflectors, lenses or other optical elements to redirect and concentrate the solar radiation passing through the aperture onto an absorber, the surface area of which is smaller than the aperture area.

2.6.6 *Collector, Line Focus*

A concentrating collector that concentrates solar radiation in one plane only producing a linear focus.

2.6.7 *Collector, Point Focus*

A concentrating collector that focuses solar radiation to a point.

2.6.8 *Collector, Parabolic Trough*

A concentrating collector that focuses solar radiation by means of a cylindrical reflector having a parabolic cross section.

2.6.9 *Collector Parabolic Dish*

A concentrating collector having a paraboloidal dish-shaped reflector, that focuses the solar radiation onto an attached focal-point receiver or engine-receiver unit.

2.6.10 *Collector, Non-Imaging*

A concentrating collector that concentrates solar radiation onto a relatively small receiver, but without bringing the solar radiation to a sharp point or line focus, that is without creating an image of the sun on the receiver.

2.6.11 *Collector, Compound Parabolic Concentrating*

A non-imaging concentrating collector that uses parabolic reflector segments to concentrate the solar radiation.

2.6.12 *Collector, Faceted*

A concentrating collector that uses many flat reflecting elements to concentrate the solar radiation at a small area or along an elongated band.

2.6.13 *Collector, Fresnel*

A concentrating collector that uses a Fresnel lens/mirrors to focus the solar radiation onto a receiver.

2.6.14 *Collector, Tracking*

A solar collector that moves so as to follow the apparent motion of the sun during the day, rotating about one or two axis (single or double-axis tracking).

2.6.15 *Collector, Evacuated Tube*

A solar collector made from transparent tubing (usually glass) with an evacuated space (Partial vacuum) between the tube wall and the absorber. The absorber may consist of an inner tube or another shape with means for removal of the thermal energy and may be specially coated.

2.6.16 *Collector, Trickle*

A flat plate solar collector in which unpressurized liquid flows or 'trickles' over the absorber.

2.6.17 *Collector, Venetian Blind*

An air-type solar collector in which movable vans are employed to absorb or reject the radiant energy.

2.6.18 *Collector Vertical Wall*

A solar collector which is placed on a vertical wall (with a tilt angle of 90 degrees).

2.6.19 *Collector, Site Assembled*

A solar collector which is assembled only at the site of its installation.

NOTE — This may be because parts of the building (rafters, insulation etc.) are part of the collector or because the size of the collector makes transportation impractical.

2.7 Collector Components

2.7.1 *Absorber*

Device within a solar collector for absorbing radiant energy and transferring this energy as heat into a fluid.

2.7.2 *Absorber Plate*

An essentially planar form of absorber.

2.7.3 *Receiver*

In concentrating collector, the part to which the solar radiation is finally directed or redirected and includes the absorber and any associated glazing through which the radiation must pass.

2 7.4 *Non-Selective Surface*

A surface of which the optical properties of reflectance, absorptance, transmittance and emittance are spectrally uniform, that is essentially independent of wavelength, over a particular wavelength range.

2.7.5 *Selective Surface*

A surface of which the optical properties of reflectance, absorptance, transmittance and emittance are spectrally dependent that is significantly vary with wavelength, so that the collection (or rejection) of thermal energy is enhanced.

2.7.6 *Cover Plate Collector*

The transparent (or translucent) material or materials that cover the absorber of a solar collector to provide thermal and environmental protection.

NOTE — These materials are most directly exposed to the solar radiation and are generally used to reduce the heat loss from the absorber to the surroundings and to protect the absorber.

2.7.7 *Collector Aperture (A)*

Net area available for transmission of solar radiation through the outer air cover interface.

2.7.8 *Aperture Plane*

The plane at or above the solar collector through which the unconcentrated solar radiation is admitted.

2.7.9 *Area, Aperture*

The maximum projected area of a solar collector through which the unconcentrated solar radiation is admitted and directed to the absorber.

2.7.10 *Area, Collector Panel*

The total area of the panel assembly with its containing box (if present), projected on the aperture plane.

2.7.11 *Area, Gross Collector*

The maximum projected area of a completed solar collector module, exclusive of integral means of mounting and connecting fluid conduits. For an array or assembly of collectors including devices, such as evacuated tube or concentrating collectors, gross area includes the entire area of the array.

2.7.12 *Concentrator*

An optical device (consisting of lenses or mirrors) which as part of a solar collector, receives the unconcentrated solar radiation and redirects (concentrates) it onto a smaller area (the receiver or absorber).

2.7.13 *Equatorial Mount*

A sun-tracking mount, usually clockwork-driven, whose axis of rotation is parallel to the earth's axis.

2.7.14 *Fresnel Lens*

A sheet of plastic or glass, having grooves of prismatic section, which refract the incoming radiation as desired, usually to a line or point focus.

2.7.15 *Fresnel Lens, Circular*

A fresnel lens, having concentric circular grooves, formed so that the radiation will be focused to a point, as by a circular lens.

2.7.16 *Fresnel Lens, Linear*

A fresnel lens, having parallel straight grooves formed so that the radiation will be focused to a line, as by a cylindrical lens.

2.8 Collector Attributes and Operation

2.8.1 *Heat Transfer Fluid*

A fluid that is used to transfer thermal energy between components in a system.

2.8.2 *Fluid Inlet Temperature*

The temperature of the heat transfer fluid at the point of entry into the collector.

2.8.3 *Fluid Outlet Temperature*

The temperature of the heat transfer fluid at the point of leaving the collector.

2.8.4 *Mean Fluid Temperature*

The average temperature of the heat transfer fluid in the collector. Its value is usually taken to be the arithmetic mean of the fluid inlet and outlet temperatures.

2.8.5 *Nominal Working Pressure*

The recommended working pressure for which the collector was designed and built.

2.8.6 *Efficiency, Collector*

Of a solar thermal collector, the ratio of the energy removed by the heat transfer fluid over a specified time period, to the solar irradiance incident on the collector for the same period, under steady-state conditions.

NOTE — For flat plate collectors the amount of solar energy may be taken over either the net (aperture), or the gross collector area, which must be stated; for concentrating collectors the amount is usually taken over the aperture area.

2.8.7 *Efficiency, Zero Loss Collector*

The efficiency of the collector, when the mean fluid temperature is equal to the ambient air temperature.

2.8.8 *Collector Heat Removal Efficiency Factor*

The ratio of the useful energy delivered by a flat plate solar collector, to what this energy would be if the entire absorber plate were at the temperature of the fluid at the inlet.

NOTE — In some test methods the mean fluid temperature is used.

2.8.9 *Collector Tilt Angle*

The lower angle between the aperture plane of a solar collector and the horizontal plane.

2.8.10 *Flow Condition*

The state obtained when the heat transfer fluid is flowing through the collector, or collector array, as intended for normal operating conditions.

2.8.11 *Stagnation Conditions*

In solar energy systems, the conditions (that is temperature and pressure) existing when the system has attained a quasi-steady state after the flow of the heat transfer fluid has stopped, but the absorber continues to receive significant solar radiation.

NOTE — In certain testing situations this term is used for the worst possible conditions, that is when the collector contains no fluid and is exposed to maximum radiation and outdoor temperature.

2.8.12 *Steady-State*

Occurring in solar collectors when the heat removal rate (including losses) is equal to the solar energy input rate, that is when the total system enthalpy is constant.

NOTE — Tolerance limits of variability may be specified for particular purposes.

2.8.13 *Concentration Ratio, Flux*

Ratio of the irradiance on the absorber of a concentrating collector, to the irradiance on the aperture of the collector.

NOTE — Normally the net aperture area is used.

2.8.14 *Concentration Ratio, Geometric*

Ratio of the aperture area of a concentrating collector, to the absorber area.

NOTE — Normally the net aperture area is used.

2.8.15 *Tracking Error*

a) for a two-axis tracking collector : the angular deviation of the outward normal line from the aperture plane from the collector-to-sun line;

b) for a single-axis tracking collector : the angular deviation between two planes intersecting along the axis of rotation, one containing the optical axis, the other containing the center of the sun.

2.8.16 *Ambient Air*

Air in the space (either indoors or outdoors) surrounding the thermal energy storage device or solar collectors, whichever is applicable.

2.8.17 *Fluid Transport*

The transfer of air, water or other fluid between components.

2.8.18 *Auxiliary Fuel*

That fuel used in an auxiliary thermal source.

2.8.19 *Auxiliary Thermal (Heat) Source*

A source of thermal energy, other than solar, used to supplement the output provided by the solar energy system; usually in the form of electrical resistance heat or thermal energy derived from combustion of fossil fuels.

2.8.20 *Domestic*

Refers to use in residential and small commercial buildings.

2.8.21 *Fractional Energy Savings*

That fraction of energy used by a conventional domestic water heating system that is saved by using the solar system.

2.8.22 *Outside Air*

Refers to external air; the atmosphere exterior to the building.

2.8.23 *Potable*

Means suitable for human consumption.

2.8.24 *Solar Fraction*

The ratio k of energy supplied by the solar part of a system to the total load.

2.8.25 *Standby Condition*

That condition of operation in which no energy is deliberately being put in or withdrawn from the tank.

2.8.26 *Temperature, Ambient Air*

The temperature of the air surrounding the thermal energy storage device or solar collectors being tested.

NOTE — Significant differences can occur over short distances, therefore, in particular applications, the method of measurement must be specified.

2.8.27 *Time Constant*

The time required for a first order system to have its output change by 63·2 percent of its final change in output following a step change in its input.

2.8.28 *Water Draw Rate*

The rate at which the hot water is withdrawn from the system at a specified time.

2.8.29 *Equivalent Length*

The length of a straight section of pipe or duct causing the same pressure drop as actually occurs within the system at the same flow rate.

2 8.30 *Tank Capacity*

The measured volume of the fluid in the tank when full.

2.8.31 *Accuracy*

The ability of an instrument to indicate the true value of the measured physical quantity.

2.8 32 *Precision*

The measure of the closeness of agreement among repeated measurements of the same physical quantity.

2.8.33 *Standard Air*

Air weighing 1·204 kg/m^3 which approximates dry air at temperature of borometric pressure of 101·325 kPa.

2.8.34 *Standard Barometric Pressure*

The barometer pressure of 101·325 kPa.

2.8.35 *Class A Operation*

Mode of operation in which the delivery temperature at the hot outlet connection never falls below 57°C under a specified load.

2.8.36 *Class B Operation*

Mode of operation in which the delivery temperature at the hot outlet connection never falls below 45°C under a specified load.

2.8.37 *Load*

Amount of thermal energy drawn from the system as hot water during a particular test (for example the average day test, or the non-solar test).

2.8.38 *Solar Contribution*

The ratio of energy supplied by the solar part of a system to the total load.

2.8.39 *Storage Tank Volumetric Capacity*

The measured volume of the fluid in the tank when full.

2.8.40 *Continuous Electricity Tariff*

Tariff for continuously available electricity supply.

2.8.41 *Off-Peak* (*Electricity*) *Tariffs*

Tariff for electricity supply for restricted hours. There may be different tariffs for different restricted periods.

2.9 Systems

2.9.1 *Circulating System*

A system in which heat transfer fluid circulates between the collector and a storage vessel or heat exchanger during operating periods.

2.9.2 *Close-Coupled — Solar Water Heater*

Unit where the collector abuts the container on a common chassis or cradle.

2.9.3 *Closed System* (*Sealed or Unvented System*) A system in which the heat transfer fluid is completely sealed from the atmosphere.

2.9.4 *Direct System*

A system in which the heated water that will ultimately be consumed passes through the collector.

2.9.5 *Drainback System*

A solar thermal system in which, as part of the normal working cycle, the heat transfer fluid is drained from the solar collector into a storage vessel for subsequent reuse.

2.9.6 *Draindown System*

A solar thermal system in which the heat transfer fluid can be drained from the collector and run to waste.

2.9.7 *Filled System*

A system in which the collector remains filled with the heat transfer fluid.

2.9.8 *Forced System*

A system in which heat transfer fluid is forced through the collector either by mechanical means or by externally generated pressure.

2.9.9 *Indirect System* (*Heat Exchange System*)

A system in which a heat transfer fluid other than the heated water ultimately consumed passes through the collector.

2.9.10 *Integral Collector Storage System*

A system in which the functions of collection and storage of solar energy are performed within the same device.

2.9.11 *Open System*

A system in which the heat transfer fluid is in extensive contact with the atmosphere.

2.9.12 *Remote Storage System*

A system in which the storage vessel is separate from the collector and is located at some distance from it.

2.9.13 *Series — Connected System*

A system in which the water to be heated passes directly from a supply point through the collector to a storage vessel or to a point of use.

2 9.14 *Service Hot Water System*

A system to supply hot water for use in domestic or commercial applications other than space heating.

2.9.15 *Solar Water Heater*

System normally consisting of a collector and a container which may be integral, close coupled or remote, and which heats water by means of radiant energy from the sun. It is normal for solar water heaters to be either fitted with or connected to a supplementary heating source.

2.9.16 *Solar Only Systems*

A system designed to provide solar heated domestic water without use of supplementary energy other than that required for fluid transport and control purposes.

2.9.17 *Solar Preheat System*

A system not incorporating any form of supplementary heating and installed to preheat cold water prior to its entry into any other type of household water heater.

2.9.18 *Solar Plus Supplementary System*

A system which utilizes both solar and an auxiliary energy source in an integrated way and is able to provide a specified hot water service independently of solar energy availability.

2.9.19 *Thermosiphon System*

A system which utilizes only density changes of the heat transfer fluid to achieve circulation between collector and storage.

2.9.20 *Vented System*

A system in which contact between the heat transfer fluid and the atmosphere is restricted either to the free surface of a feed and expansion cistern or to an open vent pipe only.

2.9.21 *Phase Change Solar System (Water Heater)*

A solar energy system which uses a refrigerant (typically freon) as the heat transfer fluid. The refrigerant changes from liquid to gas (changes phase) when it is heated, and from gas, back to liquid when heat is released. (Also known as "refrigerant-charged system".)

2.10 System Components (Other than Collectors)

2.10.1 *Collector Loop Heater*

A heater installed within the collector loop when testing the solar domestic water heating system with a non-irradiated array.

2.10.2 *Components*

Parts of the solar hot water system including but not limited to collectors, storage, pumps, heat exchanger, controls, etc.

2.10.3 *Control*

Any device for regulation of the solar thermal system or component in normal operation, can be manual or automatic.

2.10.4 *Heat Exchanger*

A device specifically designed to transfer heat between two physically separated fluids. Heat exchangers can have either single or double walls.

2.10.5 *Pressure-Temperature Relief Device*

An automatic pressure and temperature sensitive device actuated by a predetermined internal pressure or temperature or both and intended to prevent or relieve excessive pressure or temperature within an otherwise closed liquid system.

2.10.6 *Container*

Vessel (including fittings) in which the heated water is stored; sometimes referred to as a storage container, cylinder or tank.

2.10.7 *Thermopile*

A number of thermocouples wired consistently in series or parallel to measure small or average temperature difference.

3 NOMENCLATURE FOR SOLAR ENERGY CONVERSION

3.1 Letter Symbols

A	Area
a	Correlation Coefficient
AM	Air Mass
B	Supplementary Energy Source Rating
b	Correlation Coefficient
C	Cost
c	Specific Heat Capacity; Correlation Coefficient
D	Mass Diffusion Coefficient; Mass Diffusivity; Daily Total Diffuse Radiation
E	Energy; Equation of Time; Radiant Emissive Power; Illuminance; Irradiance; Radiant Flux Density
E_s	Solar Irradiance
e	Emissive Power; Fractional Energy Savings
f	Solar fraction; Monthly Fraction by Solar Energy; Focal Length
G	Solar Irradiance; Mass Flux Density; Irradiation; Daily Solar Radiation
H	Daily Irradiation; Radiant Exposure; Irradiance
h	Heat Transfer Coefficient; Planck's Constant; Specific Enthalphy
I	Hourly Irradiation; Radiant Intensity
I_s	Solar Irradiance
J	Mechanichal Equivalent of Heat; Radiosity
K	Incident Angle Modifier
k	Thermal Conductivity
L	Longitude; Length; Distance; Loss; Load; Radiance Luminance
M	Radiant Exitance; Radiosity; Radiant Flux Density
M_s	Radiant Emissive Power; Radiant Self-exitance; Radiant Exitance
m	Mass: Air Mass
$\dot{m}$	Mass Flow Rate
N	Number
n	Index of Refraction; Number
P	Power; Atmospheric Pressure; Radiant Flux
Q	Energy per Unit Time; Energy; Radiant Energy

q	Energy per Unit Time per Area or Length
R	Thermal Resistance
r	Reflection (from surface); Angle of Incidence
s	Shade Factor
sf	Solar Fraction
T	Temperature, °K
t	Temperature, °C
U	Overall Heat Transfer Coefficient
V	Average Wind Speed; Volume
v	Specific Volume
W	Radiant Energy Density; Air Speed
Z	Sun Declination Angle

3.2 Greek Symbols

α	Absorptance; Thermal Diffusivity; Absorptivity; Altitude Slope; Volumetric Thermal Expansion Coefficient, Angle
β	Luminance Factor
γ	Specific Heat Ratio; Intercept Factor; Azimuth
δ	Declination; Thickness; Dispersion; Optical Intercept Factor
ϵ	Emittance; Emisivity
η	Efficiency; Dynamic Viscosity
k	Extinction Coefficient, Wavenumber
θ	Angle; Time; Angle of Incidence
λ	Wavelength; Thermal Conductivity
μ	Absolute (Dynamic) Viscosity
ν	Kinematic Viscosity; Frequency
ρ	Reflectance; Reflecticity; Density
σ	Stefan-Boltzman Contant; Optical Beam Spread; Extinction Coefficient
τ	Transmittance; Transmissivity; Dimensionless Time
ϕ	Latitude; Radiant Flux Density
ψ	Angle
ω	Solid Angle; Hour Angle

3.3 Subscripts

a	air, ambient, absorbed, aperture, annual
av	average
b	blackbody, beam
d	diffuse, day
d_n	direct normal
e	effective, equivalent
f	final
g	gross
h	horizontal
i	incident, inlet, initial
m	maximum
n	normal, noon
o	overall, extraterrestrial, standard, outlet
p	pressure
r	reflected, radiation, receiver
s	solar, specular, scattered, system, supplementary
s_c	Solar constant
s_r	sunrise
s	sunset
T	tilted, total
t	tilted, thermal, total
th	thermal
u	useful
v	volume
z	zenith
λ	wavelength

3.4 Listing by Terms (excluding subscripts)

Absolute (Dynamic) viscosity μ, η

Absorptance α

Absorptivity α

Air Mass AM, m

Air Speed W

Altitude α

Angle θ, ψ, ϕ, ρ, ω

Angle of Incidence r, θ

Area A

Atmospheric Pressure P

Average Wind Speed V

Azimuth Y

Correlation Coefficient a, b, C, c

Cost C

Daily Irradiation H

Daily Solar Radiation G

Daily Tolal Diffuse Radiation D

Declination δ

Density ρ

Dimensionless Time τ

dispersion δ

Distance L

Efficiency η

Emissive Power E

Emisivity ϵ

Emittance ϵ

Energy E

Energy per Unit Time $\dot{Q}$
Energy per Unit Time per Unit Area or Length q
Equation of Time E
Extinction Coefficient k, σ
Flux J
Focal Length f
Fractional Energy Savings e
Frequency γ
Heat Transfer Coefficient h
Hour Angle ω
Hourly Irradiation I
Illuminance E
Index of Refraction n
Intercept Factor τ
Irradiance E, H
Irradiation H, G
Kinetic Viscosity ν
Latitude φ
Length L
Load L
Longitude L
Loss L
Luminance L
Luminance Factor β
Mass m
Mass Diffusion Coefficient D
Mass flow Rate $\dot{m}$
Mass Flux Density G
Mechanical Equivalent of Heat J
Monthly Fraction by Solar Energy f
Number N, n
Optical Beam Spread σ
Optical Intercept Factor δ
Overall Heat Transfer Coefficient U
Planck's Constant h
Power P
Radiance L
Radiant Emissive Power M_s, e
Radiant Energy Q, Q_e
Radiant Energy Density w
Radiant Exitance M, J
Radiant Exitance, Emitted M_s, E
Radiant Exposure G, H
Radiant Flux P
Radiant Flux Density E, M
Radiant Intensity L, I
Reflectance ρ
Reflection r
Shade Factors f_1
Slope β
Solar Fraction f, S_f
Solar Irradiance E_s, G, I_s
Solid Angle ω
Specific Enthalphy h
Specific Heat Capacity c
Specific Heat Ratio γ
Specific Volume v
Stefan-Boltzman Constant σ
Sun Declination Angle Z
Supplementary Energy Source Rating B
Temperature T, t
Thermal Conductivity (Boltzmann's Constant) κ, λ
Thermal Diffusivity α
Thermal Resistance R
Thickness δ, d
Time τ, θ, t
Transmittance τ
Volume V
Volumetric Thermal Expansion Coefficient β
Wavelength λ
Wavenumber κ
Zenith Angle θZ

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